International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN(P): 2249–6890; ISSN(E): 2249–8001
Vol. 9, Issue 6, Dec 2019, 183–190

PERFORMANCE AND EMISSION CHARACTERISTICS OF A TWIN CYLINDER DI DIESEL ENGINE RUNNING ON DIESEL-WASTE COOKING METHYL ESTER BLEND

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ABSTRACT

A DI Simpsons Tractor Diesel engine was investigated for performance and emissions with three different fuels namely Diesel, WCO (B100) and DWME (B20) blend. The fuel properties have been investigated with ASTM standard testing methods. It was noticed that, the pressure inside the cylinder are 90 bar, 89.29 bar, and 86.35 bar respectively, for Diesel, B100 and B20. Further, it was noticed that B20 blend leads to increase the NOx in exhaust gas.

KEYWORDS: Diesel Engine, Performance, Biodiesel, Physio Chemical Properties & Emission

Received: Jun 13, 2019; **Accepted:** Jul 08, 2019; **Published:** Oct 14, 2019; **Paper Id.:** IJMPERDDEC201916

Original Article

1. INTRODUCTION

Increasing the vehicle population causing the petroleum products consumption and has led to oil crises, global environmental degradation and health hazards in the recent years [1]. About two third of petroleum is imported from oil and petroleum exporting countries in India [2]. Indian economy is growing at the level of 6% and expected to rise 622 MT by 2047 [3]. Generally renewable energy sources and biomass energy are capable of reducing the dependency on import of fuel, by the way of increasing the energy supply. Biomass feed stocks provide alternative substitute of petroleum products. Biodiesel is extracted from animal fat and vegetable oil. Moreover, there is no traces of petroleum components in biodiesel but it can be blended to diesel at any volume ratio to produce a biodiesel blends. Valente et al. [4] investigated the physical-chemical characteristics of WCO and castor oil biodiesel with neat diesel. Mofijur et al. [5] reviewed the use of biofuels on engine emission reduction. They noticed that biofuel has potential to reduce more than 80% emission of green house gas. Jadwiga and Ziolkowska [6] identified and discussed the several potential feed stock going to be used in the near future for second generation biofuel production. Liaquat et al. [7] analysed the engine characteristics for diesel using different blends. They found that Nox emission was increased for all the fuel blends when compared to neat diesel. They observed that W5B5 produced better results compared with JB10. Pushparaj and Ramabalan [8] experimented the usage of diethyl ether ethanol as an additive to biodiesel/diesel blends, they found that emissions for B20 blend with 10% diethyl ether fairly reduced, and also Nox was reduced by 51% when compared to diesel. Yunus et al. [9] found that higher CO, CO_2 and NOx produced from all biodiesel blended fuel due to the higher content of oxygen in the biodiesel and higher exhaust temperature during the combustion. Hemanandh and Narayanan [10] conducted the experiments by using hydrotreated and refined condition of sunflower oil as a fuel in compression ignition engine. Attention has been initiated now–a-days to replace the petroleum products in transport sectors by the way of developing the alternative fuel.

In the present study, an attempt was made to analyze the performance and emission characteristics of a twin cylinder Direct Injection Simpsons make (S217) Diesel engine running on Diesel, waste cooking oil (B100) and Diesel-Waste cooking Methyl Ester (B20) blend.

2. PRODUCTION PROCESS OF BIODIESEL

Waste cooking-oil was collected from the local restaurant in Chennai, Tamil Nadu. Transesterification method was used to produce the biodiesel. The collected waste cooking-oil was filled in the flask and preheated upto 65°C. Catalyst of NaOH in 1% by weight of WCO was dissolved in methanol solution of 6:1 M ratio methanol to WCO. The solution was allowed to react 1.5 hours in a flask and finally the glycerol was removed from the biodiesel. The prepared Biodiesel was washed using warm water, the methanol residue and water were removed by using a rotary evaporator at 80°C and the waste cooking oil methyester was dried at 100°C. The prepared biodiesel was mixed with neat diesel at proportions of 20% by volume. Figure 1 shows the photographic view of (a) B20 blend and (b) B100. The fuel properties were measured for neat diesel, B100 and B20 blend presented in the below Table-1.

(a) (b)

Figure 1: Photographic view of the Prepared Blend (a) B20 and (b) B100.

Table 1: Shows the Fuel Properties of B100, B20 Compared to Neat Diesel

Fuel	Diesel	B100	B20
Density kg/m^3	830	901	854
Kinematic viscosity	4.2	5.79	3.25
Centane Number	60	45	39
Calorific value kJ/kg	47108	34016	38973

3. EXPERIMENTAL SET UP

A Simpsons make twin cylinder, four stroke, and DI compression engine with a developing power of 21 kW at 1500 rpm was used to conduct the experiment. Figure 2 shows the experimental setup of the engine. Specifications of diesel engine are showed in table 2. The test engine output brake power was measured by an eddy current dynamometer which was directly coupled to the test engine. An orifice and U-tube manometer were used to find the intake air flow rate and pressure drop across the orifice. Thermocouple (K-type) probes were used for temperature measurements. Smoke opacity and exhaust gas concentrations were measured by using smoke meter and gas analyser. The experiment was carried out by varying engine loads from 0, 25, 50, 75, 100 percentages under 1500 rpm as the constant speed.

Figure 2: Photographic View of the Experimental Setup.

Table 2: Shows the Specifications of the Engine

Model	Simpson S 217
Capacity	21 kW
Bore	91.44 mm
Stroke	127 mm
No. of cylinders	2
Compression ratio	18.5: 1
Combustion system	Direct Injection

4. RESULTS AND DISCUSSIONS

4.1 Brake Thermal Efficiency

Brake thermal efficiency for diesel, B100 and B20 blends with different engine load is shown in Figure 3. Efficiency of brake thermal was lower than 75% of the engine load due to the incomplete combustion and volatility of WCO biodiesel compared to diesel fuel. Further it was observed that, WCO and its blend's density were higher than the neat diesel fuel.

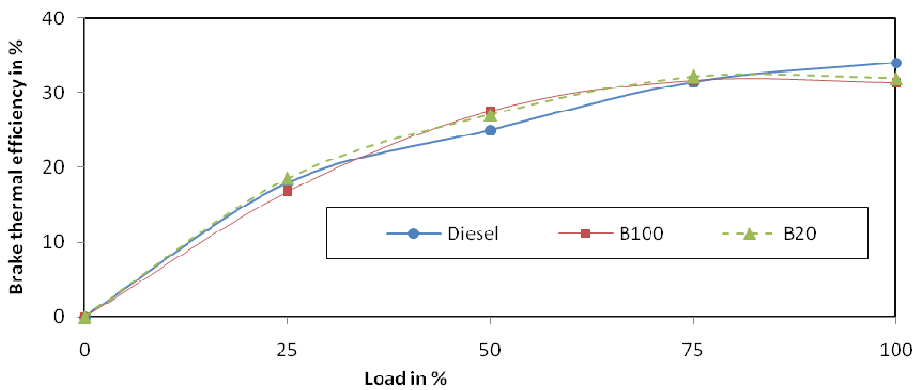

Figure 3: Variation of Brake Thermal Efficiency.

4.2. Cylinder Pressure

Figure 4 presented the cylinder pressure variation with crank angle for B100, B20 and with neat diesel at 100% load conditions. Inside the cylinder, the fuel gets well mixed with air and burn completely due to the higher cylinder pressure. It was noticed that the cylinder pressures are 90 bar, 89.29 bar, and 86.35 bar, respectively, for Diesel, B100 and B20 blend.

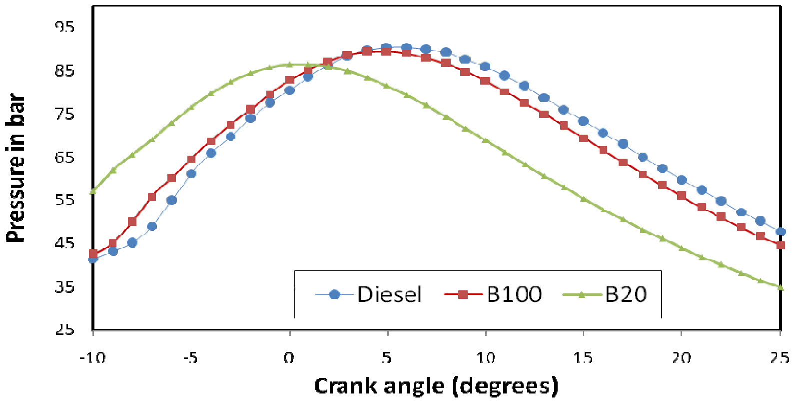

Figure 4: Variation of Cylinder Pressure at Full Load.

4.3. Exhaust Gas Temperature

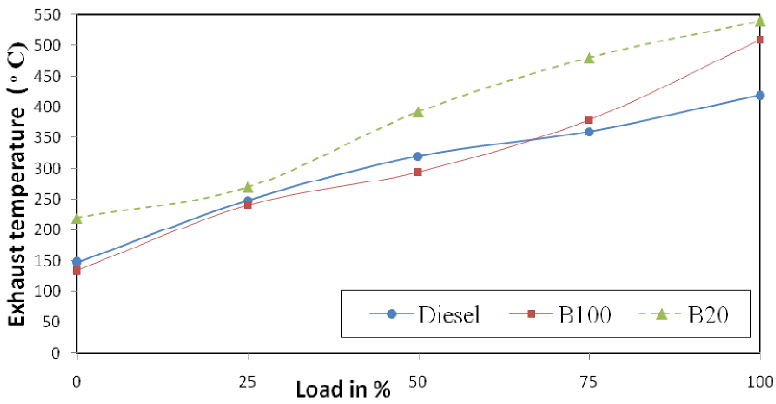

Figure 5: Variation of Exhaust Gas Temperature with Engine Load.

Figure 5 shows the exhaust gas temperature variation with engine. Exhaust gas temperature increases irrespective of the engine load for B20 blend. Due to the more amount of fuel was burnt inside the cylinder, the exhaust gas temperatures are recorded for B20 blend compared to neat diesel are higher.

4.4 NOx Emission

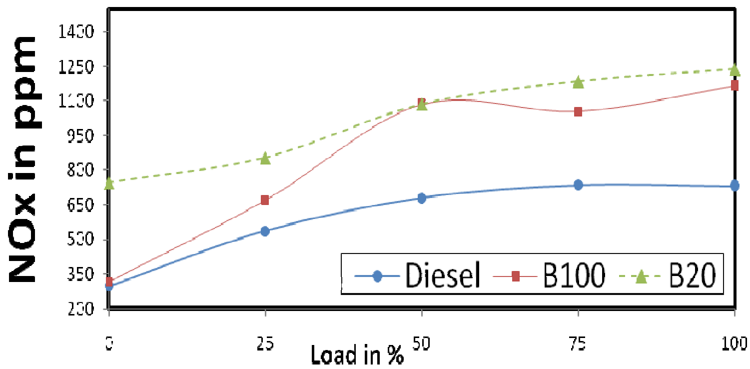

Figure 6: Variation of Nox Emission with Engine Load.

NOx emissions for B100, B20 and neat diesel with respect to engine load are shown in Figuer 6. NOx emissions were increased manner with the increase of engine load for the fuels used such as B100 and B20 when compared to neat diesel, due to the increase of fuel burned and the cylinder temperature. Normally, in a CI engine formation Nox emission

occurs due to the peak cylinder temperature.

4.5. Smoke Emission

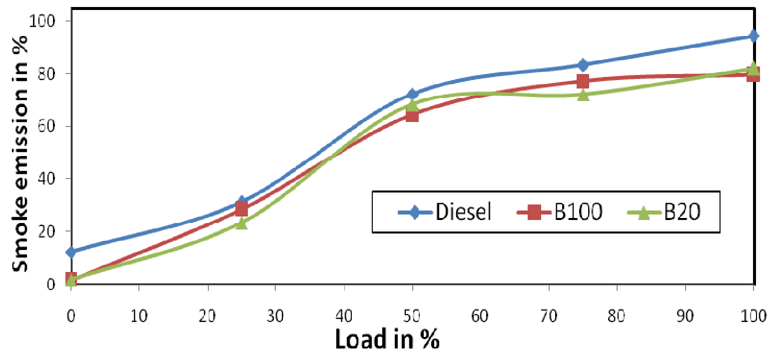

Figure 7: Smoke Emission with Various Engine Load.

Smoke emissions for B100, B20 and diesel with respect to engine load are shown in Figure 7. Smoke emissions of B100 and B20 were less than neat diesel fuel at all the load conditions, due to more oxygen in the biodiesel, it helps to complete the combustion and reduction in smoke emission.

4.6. CO Emission

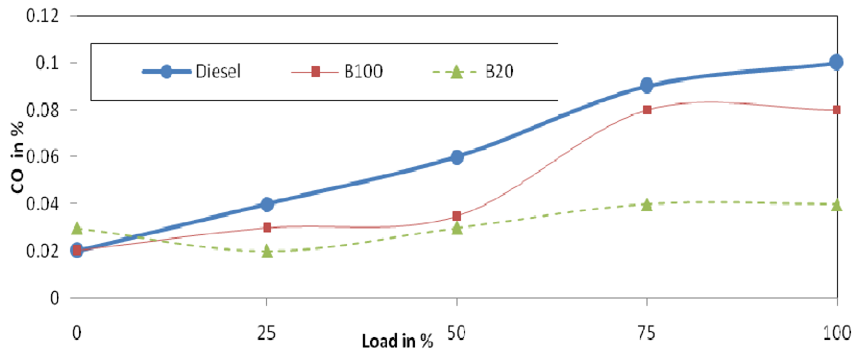

Figure 8: Variation of CO Emission.

Variations of CO emissions for B100, B20 and diesel fuel are in Figure 8. CO emissions decreased for B100 and B20 at all loads, due to oxygen molecules present more and lesser carbon content available in the biodiesel.

4.7. CO_2 Emission

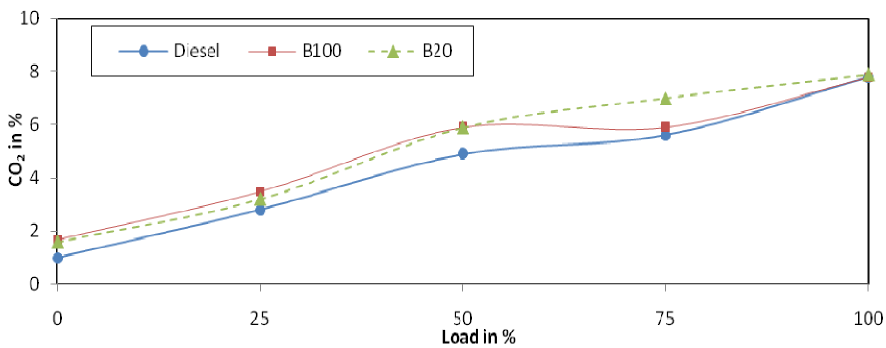

Figure 9: Variation for CO_2 Emission.

Figure 9 variation of CO_2 emission for B100, B20 and diesel fuel at all loading conditions. The trend of CO_2 emission was increased at all load conditions due to the heavier quantity of fuel entered as the load also increased.

4.8. UBHC Emission

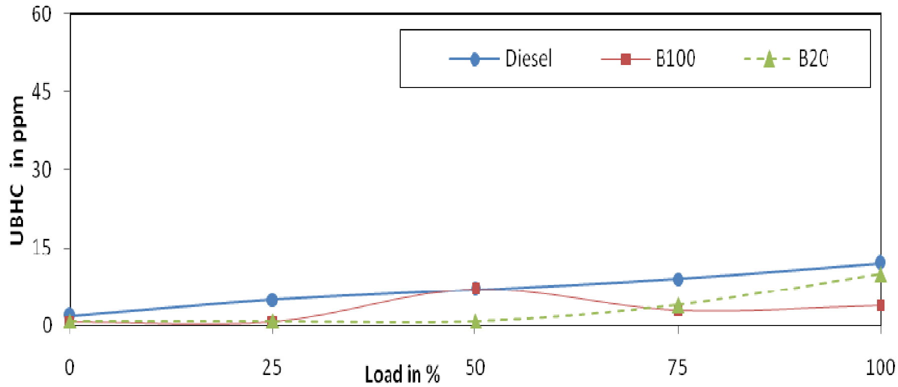

Figure 10: Variation of UBHC Emission.

Figure 10 shows the UBHC emission of B100, B20 and diesel at all load condition. UBHC emissions decreased at part load conditions but increased in nature after 50% of the load condition. It was noticed that HC emission for B20 blend was very less compared to other two fuels used it at all operating conditions.

5. CONCLUSIONS

The experiment was conducted on a Simpsons make DI compression ignition engine with a developing power of 21 kW at 1500 rpm when running on Diesel, B20 and B100. The engine characteristics were carefully measured at various engine loads from 0 to 100%. The following conclusion could be arrived as: 1) B20 blend thermal efficiency was lower when compared to other two fuels. 2) Exhaust gas temperatures are high for B20 blend compared to other fuels used it due to more amount of fuel was burnt.

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